

Research and Development



AERIAL PHOTOGRAPHIC AND FRACTURE TRACE ANALYSES OF CHLOR-ALKALI FACILITY

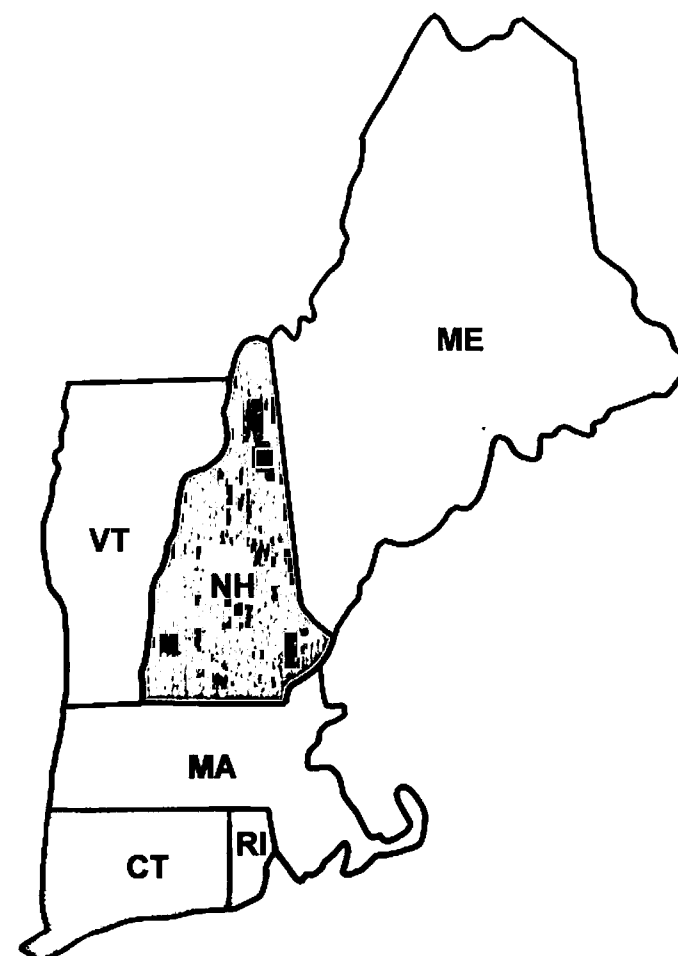
Berlin, New Hampshire



SDMS DocID

284800

EPA Region 1



TS-PIC-20801101S
February 2008

AERIAL PHOTOGRAPHIC AND FRACTURE TRACE ANALYSES OF
CHLOR-ALKALI FACILITY

Berlin, New Hampshire

by

A. S. Kartman and L. Mata
Environmental Services
Lockheed Martin Services
Las Vegas, Nevada 89119

Contract No. EP-D-05-088

Work Assignment Manager

K. Johnson
Landscape Ecology Branch
Environmental Sciences Division
Las Vegas, Nevada 89193-3478

ENVIRONMENTAL SCIENCES DIVISION
NATIONAL EXPOSURE RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
LAS VEGAS, NEVADA 89193-3478

NOTICE

This document has undergone a technical and quality control/assurance review and has been approved for publication by personnel of the U.S. Environmental Protection Agency, Office of Research and Development, Environmental Sciences Division, Landscape Ecology Branch at Las Vegas, Nevada. It is for internal Agency use and distribution only.

ABSTRACT

This report presents the findings from a historical aerial photographic analysis and a fracture trace analysis of the Chlor-Alkali Facility (Site) located in Berlin, Coos County, New Hampshire. To perform the analyses ten years of historical black-and-white and color infrared aerial photographs were obtained to cover the period from 1955 through 1994. For the historical aerial photographic analysis eight years of photography were analyzed and reproduced for inclusion in this report. The purpose of the historical aerial photographic analysis is to document landscape morphology, patterns of hazardous waste disposal, and other observable conditions of environmental significance at this 2-hectare (5-acre) site. The fracture trace assessment was conducted using two years of aerial photography. The objective of the fracture trace analysis was to identify zones of fracturing in the bedrock that could act as preferential pathways for subsurface contaminant flow. This report provides operational remote sensing information in support of remedial actions conducted by the Region 1 Office of the U.S. Environmental Protection Agency (EPA) under the Comprehensive, Environmental Response, Compensation, and Liability Act (CERCLA).

Findings from the historical aerial photographic analysis of the Chlor-Alkali Facility reveal the presence of vertical and horizontal storage tanks and overhead pipelines from 1955 through at least 1965 on the site. Later between 1965 and 1969, buildings, portions of buildings, and a railroad marshalling yard were removed from the site. Disturbed ground, possible stains, and a possible dump area were noted on the site in 1969. In 1976 runoff trails were noted on rock outcrops adjacent to the site in the Androscoggin River. In addition, containers and stained ground were visible at an offsite location east of the site.

This report also presents findings from a fracture trace analysis of the Chlor-Alkali Facility and the area within approximately 41 square kilometers (16 square miles) of the site. The fracture trace analysis was performed

using black-and-white aerial photographs acquired in 1964 and 1982. A total of seven (7) fracture traces were identified proximal to the Chlor-Alkali Facility.

The EPA Environmental Sciences Division, Landscape Ecology Branch in Las Vegas, Nevada, prepared this report for the EPA Region 1 Superfund Division in Boston, Massachusetts, and the EPA Office of Superfund Remediation Technology Innovation in Washington, D.C.

CONTENTS

	<u>Page</u>
Abstract	iii
Introduction	1
Methodology	6
Historical Aerial Photographic Analysis	13
Fracture Trace Analysis	33

FIGURES

Number

1 Site location map, New Hampshire	4
2 Local site location map, Berlin, New Hampshire	5
3 Chlor-Alkali Facility, Sanborn map, 1928	10
4 Chlor-Alkali Facility, Sanborn map, 1955	11
5 Chlor-Alkali Facility, August 4, 1955	15
6 Chlor-Alkali Facility, November 4, 1964	17
7 Chlor-Alkali Facility, May 6, 1965	19
8 Chlor-Alkali Facility, September 14, 1969	23
9 Chlor-Alkali Facility, August 19, 1976	25
10 Chlor-Alkali Facility, October 11, 1982	27
11 Chlor-Alkali Facility, May 13, 1986	29
12 Chlor-Alkali Facility, May 14, 1994	31
13 Chlor-Alkali Facility, fracture trace analysis, May 13, 1986	35
Glossary	37
References	39

INTRODUCTION

This report presents the findings from a historical aerial photographic analysis and a fracture trace analysis of the Chlor-Alkali Facility (Site) (CERCLIS ID# NHN000103313) located in Berlin, Coos County, New Hampshire (Figures 1 and 2). To perform these analyses ten years of historical black-and-white and color infrared aerial photographs were obtained to cover the period from 1955 through 1994. For the historical aerial photographic analysis, eight years (1955, 1964, 1965, 1969, 1976, 1982, 1986, and 1994) were analyzed and reproduced for inclusion in this report. The purpose of the historical aerial photographic analysis was to document landscape morphology, patterns of hazardous waste disposal, and other observable conditions of environmental significance at the facility. The fracture trace analysis was performed for the area within approximately 41 square kilometers (16 square miles) of the site using black-and-white archival aerial photographs. The objective of the fracture trace analysis was to identify zones of fracturing in the bedrock that could act as preferential pathways for subsurface contaminant flow. These analyses and the report provide operational remote sensing support for remedial actions conducted by the Region 1 Office of the U.S. Environmental Protection Agency (EPA) under the Comprehensive, Environmental Response, Compensation, and Liability Act (CERCLA).

The site covers approximately 2 hectares (5 acres) and is located in the industrial zone of Berlin, New Hampshire on the eastern shoreline of Androscoggin River. Site boundaries used in these analyses were determined from observations made on aerial photographs and do not necessarily denote legal property lines or ownership.

Collateral information supplied by Region 1 (EPA, 2007) states that from at least 1890, the Chlor-Alkali Facility and the area around it had been involved in paper manufacturing. From the late 19th Century through to the 1960s, a chemical mill, including the Chlor-Alkali Facility, produced the raw materials needed for the paper plant. The Chlor-Alkali Facility manufactured

chlorine gas and sodium hydroxide solution using graphite-mercury cells. The facility contained an absorption and evaporator buildings, a caustic plant, chlorine gas cell houses, a transformer house, a caustic shed, chloroform still rooms, numerous storage tanks and a hydrogen gasometer (See Figures 3 and 4 [EDR, 2007]). Soil and ground water investigations on the site have revealed elevated levels of mercury, lead, and arsenic. In addition, mercury is seeping through bedrock fractures into the Androscoggin River.

Findings for the historical aerial photographic analysis of the Chlor-Alkali Facility indicate that in 1955, 1964, and 1965 three large buildings, vertical and horizontal storage tanks, and overhead pipelines were on the site. At a railroad marshalling yard, numerous railroad freight and tanker cars are present. By 1969 all vertical storage tanks and overhead pipelines were removed from the site along with one entire building and a significant section of a second building. Disturbed ground, possible stains, and a possible dump area were identified. In 1976, no changes were seen with the buildings but a parking area was established and nearly full with vehicles. Adjacent to the site, runoff trails and a possible stain were noted on rock outcrops in the Androscoggin River. Containers and stains were identified adjacent to an offsite building located east of the site. From 1982 through at least 1986, the Chlor-Alkali Facility was not active and the marshalling yard was removed. By 1994, all railroad spurs had been removed. An open storage area, transportation trailers, and possible heavy equipment were observed at the site.

The fracture trace analysis presents findings based on the study of 1964 and 1982 black-and-white aerial photographs in conjunction with pertinent geologic literature (see References) of the Chlor-Alkali Facility and surrounding area. The objective of the fracture trace analysis was to identify zones of fracturing in the bedrock that could act as preferential pathways for subsurface contaminant flow (see Methodology Section). A total of seven (7) fracture traces were identified, locations of which are presented on an overlay to a print produced from a 1986 photograph.

A Glossary, defining features or conditions identified in this report, follows the Photographic Analysis and Fracture Trace Analysis sections. Sources for all maps, aerial photographs, and collateral data used in the

production of this report are listed in the References section. A list of all aerial photographs that were identified and evaluated for potential application to this study can be obtained by contacting the EPA Work Assignment Manager. Historical aerial photographs used in the analysis of this site have been digitally scanned and printed for use in this report. A transparent overlay with interpretative data is affixed to each of the digital prints. See the Methodology section for a discussion of the scanning and printing procedures.

The EPA Environmental Sciences Division, Landscape Ecology Branch in Las Vegas, Nevada, prepared this report for the EPA Region 1 Superfund Division in Boston, Massachusetts, and the EPA Office of Superfund Remediation Technology Innovation in Washington, D.C.

CHLOR-ALKALI FACILITY

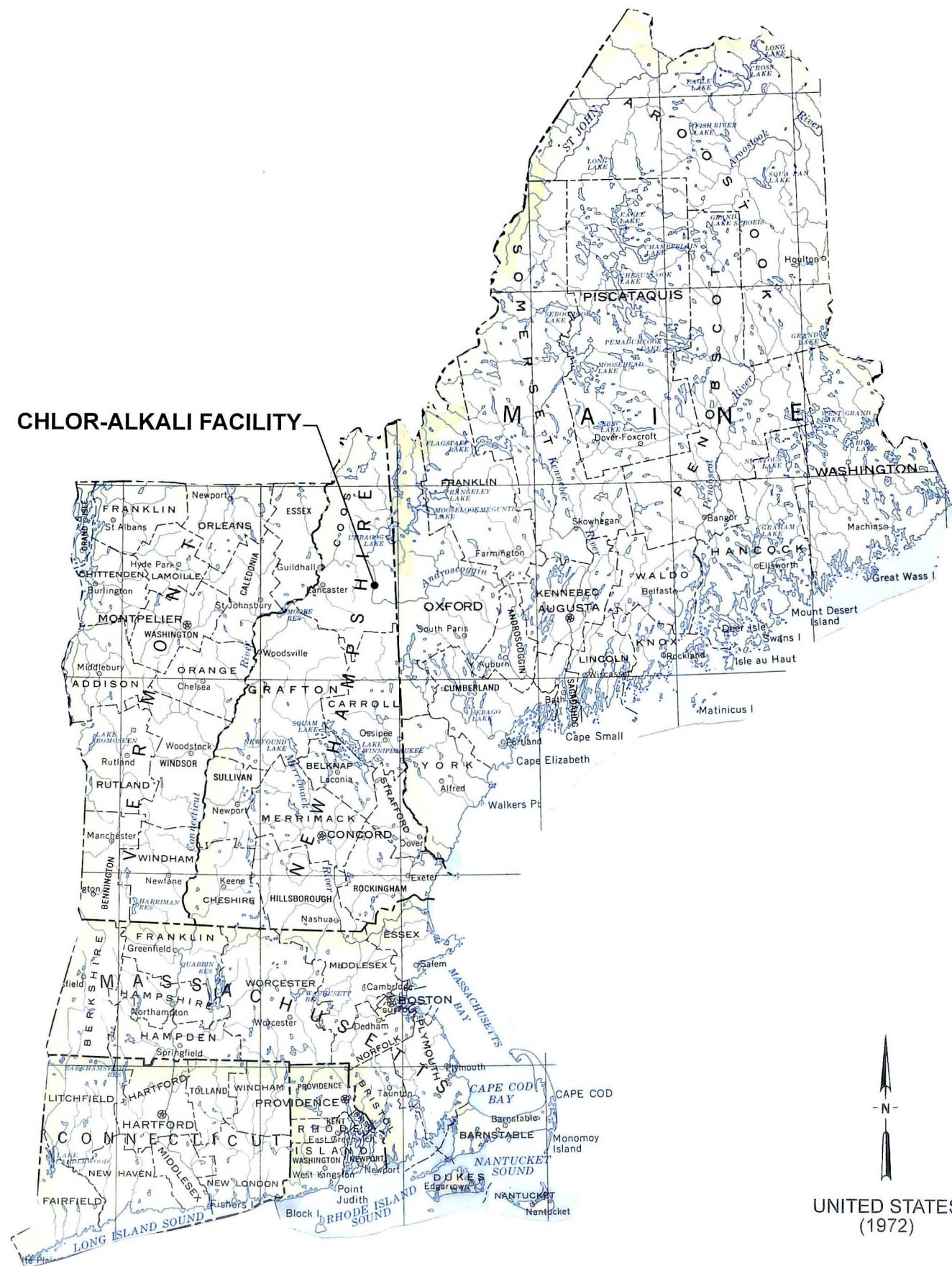


Figure 1. Site location map, New Hampshire (USGS, 1972).
Approximate scale 1:3,125,000.

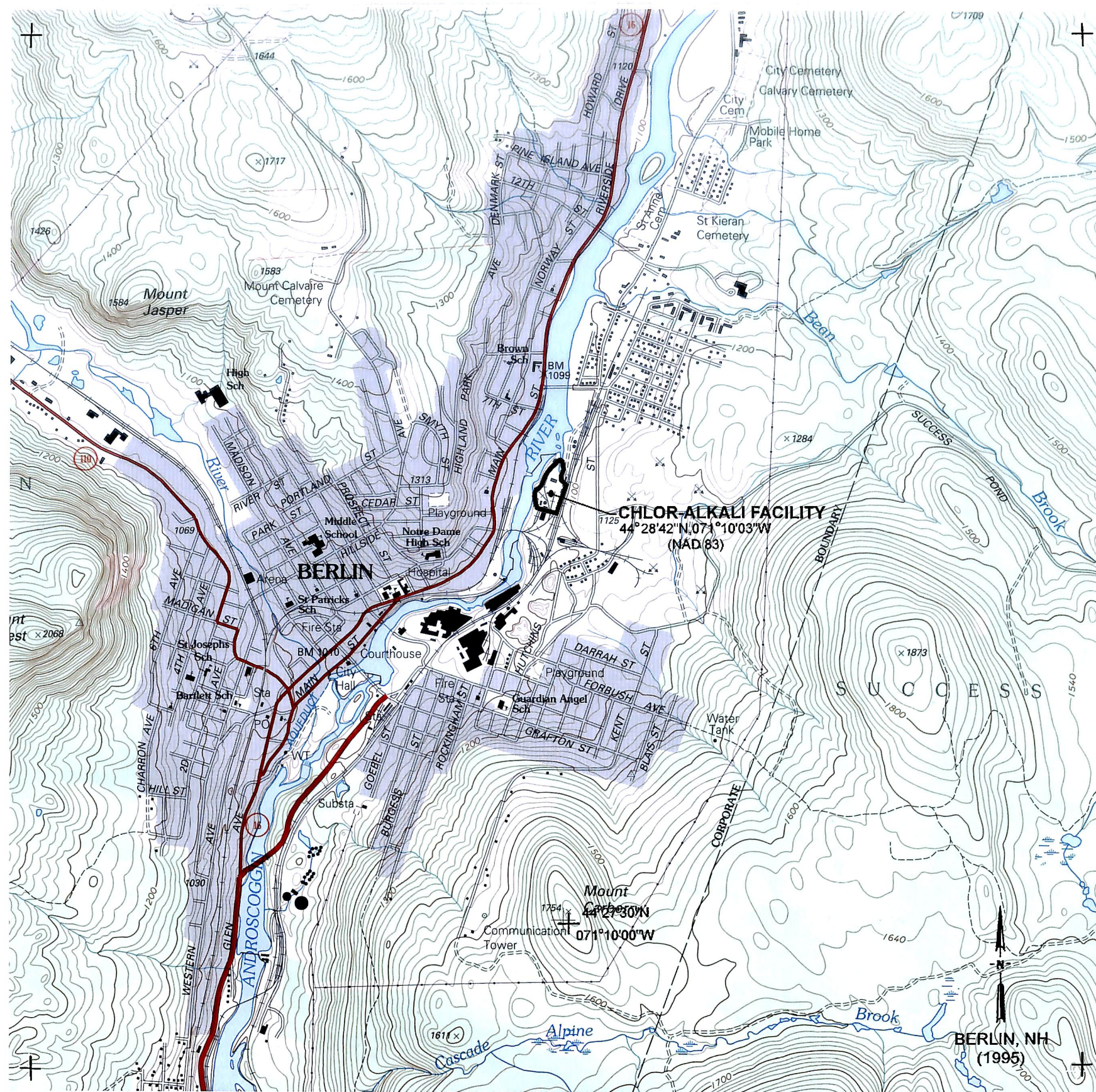


Figure 2. Local site location map, Berlin, New Hampshire (USGS, 1995).
Approximate scale 1:24,000.

METHODOLOGY

This report was prepared using a standard methodology that includes the following steps:

- data identification and acquisition,
- photographic analysis and interpretation, and
- graphics and text preparation.

These steps are described below. Subsections also address details related to specific kinds of analyses that may be required to identify environmental features such as surface drainage and wetlands. All operational steps and processes used to perform this work (including data identification and acquisition, photographic analysis and interpretation, and graphics and text preparation) adhere to strict QA/QC guidelines and standard operating procedures (SOPs). These guidelines and procedures are documented in the Master Quality Assurance Project Plan (QAPP) prepared for Remote Sensing Support Services Contract No. EP-D-05-088 (LMS, 2006).

Data identification and acquisition included a search of government and commercial sources of historical aerial film for the study area. Photographs with optimal spatial and temporal resolution and image quality were identified for acquisition. In addition, U.S. Geological Survey (USGS) topographic maps were obtained to show the study area location and to provide geographic and topographic context.

To conduct this analysis, the analyst examined diapositives (transparencies) of historical aerial photographs showing the study area. Diapositives are most often used for analysis instead of prints because the diapositives have superior photographic resolution. They show minute details of significant environmental features that may not be discernible on a paper print.

A photographic analyst uses a stereoscope to view adjacent, overlapping pairs of diapositives on a backlit light table. In most cases, the stereoscope

is capable of various magnifications up to 60 power. Stereoscopic viewing involves using the principle of parallax (observing a feature from slightly different positions) to observe a three-dimensional representation of the area of interest. The stereoscope enhances the photo interpretation process by allowing the analyst to observe vertical as well as horizontal spatial relationships of natural and cultural features.

The process of photographic analysis involves the visual examination and comparison of many components of the photographic image. These components include shadow, tone, color, texture, shape, size, pattern, and landscape context of individual elements of a photograph. The photo analyst identifies objects, features, and "signatures" associated with specific environmental conditions or events. The term "signature" refers to a combination of components or characteristics that indicate a specific object, condition, or pattern of environmental significance. The academic and professional training, photo interpretation experience gained through repetitive observations of similar features or activities, and deductive logic of the analyst as well as background information from collateral sources (e.g., site maps, geologic reports, soil surveys) are critical factors employed in the photographic analysis.

The analyst records the results of the analysis by using a standard set of annotations and terminology to identify objects and features observed on the diapositives. Significant findings are annotated on overlays attached to the photographic or computer-reproduced prints in the report and discussed in the accompanying text. Annotations that are self-explanatory may not be discussed in the text. The annotations are defined in the legend that accompanies each print and in the text when first used.

Objects and features are identified in the graphics and text according to the analyst's degree of confidence in the evidence. A distinction is made between certain, probable, and possible identifications. When the analyst believes the identification is unmistakable (certain), no qualifier is used. Probable is used when a limited number of discernible characteristics allow the analyst to be reasonably sure of a particular identification. Possible is used when only a few characteristics are discernible, and the analyst can only infer an identification.

The prints in this report have been reproduced, either by photographic or computer methods, from the original film. Reproductions are made from the original film and may be either contact (the same size) prints or enlargements, depending on the scale of the original film. Any computer-produced prints used in this report are generated from scans of the film at approximately 1,300 dots per inch (dpi) and printed at 720 dpi. Although the reproductions allow effective display of the interpretive annotations, they may have less photographic resolution than the original film. Therefore, some of the objects and features identified in the original image and described in the text may not be as clearly discernible on the prints in this report.

Study area boundaries shown in this report were determined from aerial photographs and from information supplied by EPA Region. Boundaries used in this report do not necessarily denote legal property lines or ownership.

Digital Diapositives

Some film vendors no longer supply analog film products (e.g., diapositive transparencies) to their customers. Digital files, created by scanning the original analog film products, are provided. The digital file, a representation of an original analog film product, can be analyzed either by computer viewing techniques or by creating a secondary diapositive from the digital file and viewing the secondary diapositive on a light table. The result of this process of converting an analog diapositive image to a digital file may be a reduction in the photographic resolution. A potential consequence of this in the realm of aerial photographic analysis is a lower confidence in the identification of features or conditions of environmental significance. For example, what may have been identified with certainty as "a drum" on the analog version of the diapositive may, on the digital diapositive, only be determined to be "a probable drum."

Color Infrared Photographs

Some photographs used for this analysis were made from color infrared film. Normal color film records reflected energy in the blue, green, and red portions of the electromagnetic spectrum. Color infrared film differs in that it is sensitive not only to reflected blue, green, and red energy, but also to

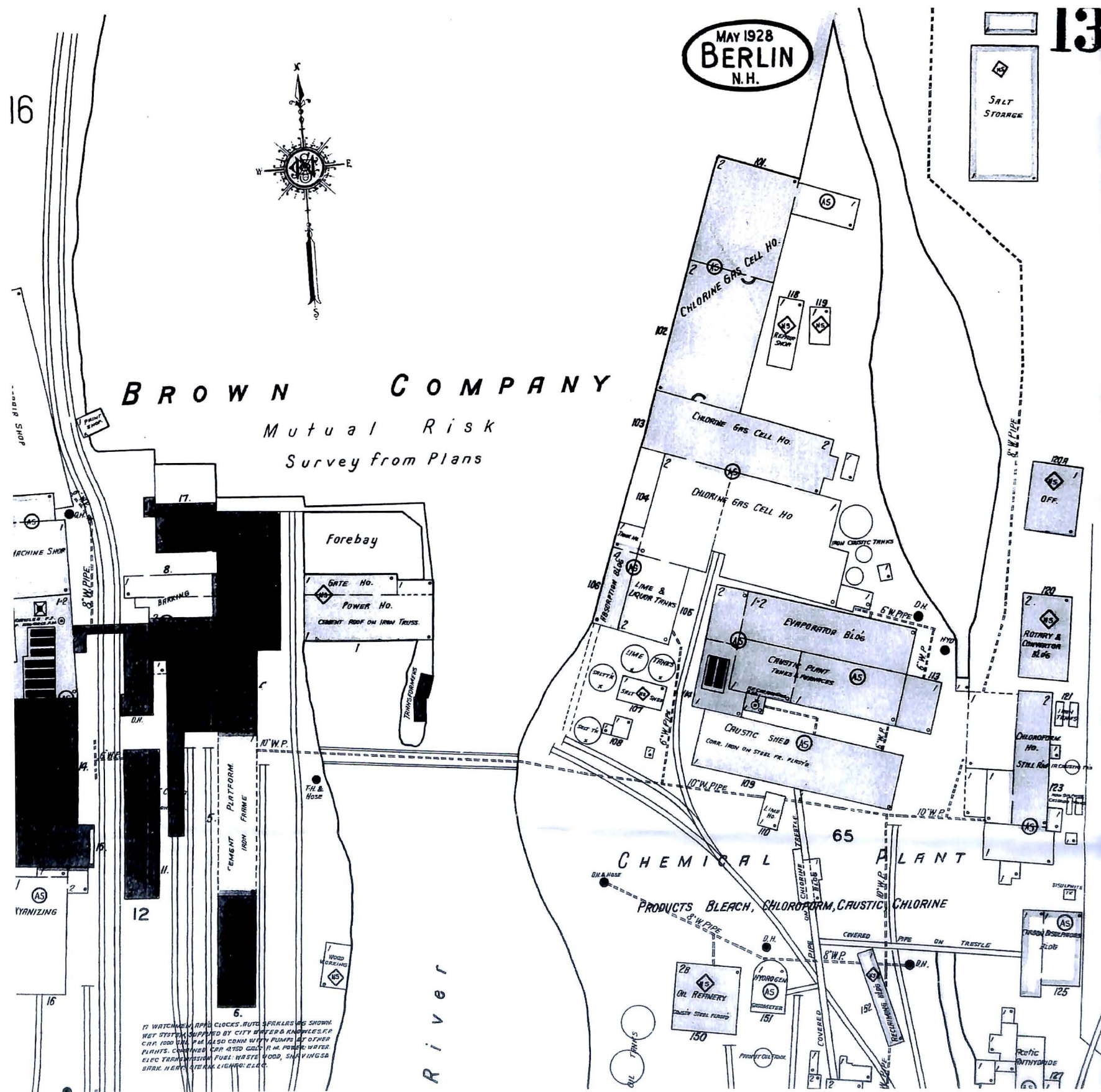
reflected energy in the infrared portions of the electromagnetic spectrum; however, the blue energy is filtered out and only the green, red, and infrared energy is recorded. When color infrared film is processed, it displays "false" colors that do not correspond with the true colors of the features photographed. For example, features that are highly reflective in the infrared portion of the spectrum, such as healthy vegetation, appear red to magenta on color infrared film. The false color displayed by a feature is produced in accordance with the proportions of green, red, and infrared energy it reflects. These portions are referred to as the "spectral reflectance characteristics" of the feature. To interpret the true color of a particular feature accurately from color infrared film, a knowledge of the spectral reflectance characteristics of that feature is required. This information is not readily available for the majority of features identified in this report. Therefore, unless otherwise indicated, no attempt has been made to interpret the true colors of the features identified on the color infrared film analyzed for this report.

Fracture Trace Analysis

Fracture trace analysis is the technique for locating fractures traces or geologic lineaments on the earth's surface. Photographic signatures such as soil-tonal variations, and vegetational and topographic alignments are identified, analyzed, and compared to known cultural and geologic information to determine if the signatures are likely to be expressions of fractures in the bedrock. Results from the fracture trace analysis are presented on clear acetate overlays to photographs or USGS topographic maps.

Surface Drainage

The surface drainage analysis produced for this report identifies the direction and potential path that a liquid spill or surface runoff would follow based on the topography of the terrain and the presence of discernible obstacles to surface flow. The analyst determines the direction of surface drainage by stereoscopic analysis of the aerial photographs and by examining USGS topographic maps. Site-specific surface drainage patterns are annotated on the map or photo overlay. Where the direction of subtle drainage cannot be determined, an indeterminate drainage line symbol is used. Regional surface flow is ascertained from the USGS topographic maps.



HISTORICAL AERIAL PHOTOGRAPHIC ANALYSIS

The Chlor-Alkali Facility (Site) is located within the city of Berlin, Coos County, New Hampshire. The site covers approximately 2 hectares (5 acres) on the eastern shoreline of the Androscoggin River. Elevations range from approximately 329 meters (1,080 feet) above sea level along the river to 332 meters (1,090 feet) in the eastern part of the site (USGS, 1995). Runoff from the site trends to the west into the Androscoggin River.

AUGUST 4, 1955 (FIGURE 5)

Structures which appear to be associated with an industrial processing facility are on the site. These structures consist of three large buildings (B1, B2, and B3), a small shed (SH), and numerous storage tanks. Access to the site is via a railroad (R/R) system and a north-south oriented access road (AR) that extends along the eastern boundary of the site north to Bridge Street. The access road will no longer be annotated or discussed in the text. Several railroad spurs, railroad freight cars and tankers, and a railroad marshalling yard are located in the southern part of the site.

Near building B1, located in the northern part of the site adjacent to the Androscoggin River, there is an open storage area (OS) containing light-toned objects (not annotated). In the northeast corner of the site there is a walking bridge. Building B2, located in the center of the site, appears to be an assemblage of numerous connected smaller buildings, amassed during past expansions. The smaller individual buildings have roof designs of different heights and shapes. Adjacent to building B2 are a vertical storage tank (VT), a probable vertical storage tank, and along the north side of the building a grouping of three vertical storage tanks. The largest of these three tanks is an open-topped tank. An overhead pipeline (OVHD PL) connects this grouping of storage tanks to building B2. A grouping of three probable vertical storage tanks and overhead pipelines is located between building B2 and the railroad marshalling yard. This area is likely used as a loading zone. In the

southeast corner of the site is building B3. A conveyor/pipeline connects this building to building B2. Also noted between these buildings is a circular patch of light-toned material (LTM).



Figure 5. Chlor-Alkali Facility, August 4, 1955. Approximate scale 1:3,600.

NOVEMBER 4, 1964 (FIGURE 6)

Buildings B1, B2, and B3 and the small shed remain at the site. Since 1955 two vertical storage tanks and three possible horizontal storage tanks (HT) have been placed along the east side of building B1. The tanks appear to be connected to building B1 by a lattice of overhead pipelines. Just to the north is a rectangular-shaped area of possible saturated material. A pipeline extends northeast from building B1 to a possible ditch which terminates at the edge of the waterway near the walking bridge. At the connection point of the pipeline and possible ditch is a patch of dark-toned material (DTM) or stain (not annotated), suggesting a collection point for liquid. The open storage area, located along the east wall of building B1, now houses crates (CR), containers (CONT), and a grouping of three probable horizontal storage tanks. A section of a railroad track, likely a remnant of a dismantled rail spur, is visible between buildings B1 and B2. Due to the relatively lower film resolution of the 1955 photograph it is not possible to ascertain if this feature is in place at that time.

Numerous vent pipes and smokestacks (SS) are noted protruding from the roof of the western section of building B2. Connected to building B2 by overhead pipelines are two groupings of two vertical storage tanks. The storage tanks located on the north side of the building were visible in 1955. Near the tanks is a light-toned possible walkway which likely extends from the building, to an unidentified structure and adjacent stain (ST). The function of this structure cannot be determined. A grouping of two vertical storage tanks is located alongside the Androscoggin River. In 1955, three probable vertical storage tanks were observed at this location. Since 1955, one storage tank has been removed, a circular-shaped tank pad remains. A vertical storage tank remains in place on the northeast side of building B2 and a horizontal storage tank is now located on southeast side of the building. Building B2 is connected to an offsite building (not annotated), located due east of the site, via an overhead pipeline. Additional overhead pipelines or possible conveyors connect building B2 to building B3. An open storage area consisting of small crates, and two probable horizontal storage tanks is located near building B3.

Numerous railroad tanker cars are parked in the marshalling yard and adjacent to buildings B2 and B3.



LEGEND

	SITE BOUNDARY
	FLOW
	ACCESS ROAD
	RAILROAD
	EXCAVATION/PIT
	MOUNDED MATERIAL
	ESCARPMENT
AR	ACCESS ROAD
B	BUILDING
CA	CLEARED AREA
CIR	CIRCULAR
CONT	CONTAINER
CR	CRATE
CYL	CYLINDRICAL-SHAPED
DER	DERELICT
DG	DISTURBED GROUND
DT	DARK-TONED
FOR	FORESTED
GS	GROUND SCAR
HE	HEAVY EQUIPMENT
HT	HORIZONTAL TANK
IND	INDUSTRIAL
LT	LIGHT-TONED
M	MATERIAL
MM	MOUNDED MATERIAL
OBJ	OBJECT
OS	OPEN STORAGE
OVHD	OVERHEAD
PL	PIPELINE
RECT	RECTANGULAR
RES	RESIDENTIAL
R/R	RAILROAD
SH	SHED
SQ	SQUARE-SHAPED
SS	SMOKESTACK
ST	STAIN
UO	UNIDENTIFIED OBJECT
VEG	VEGETATION
VEH	VEHICLE
VT	VERTICAL TANK

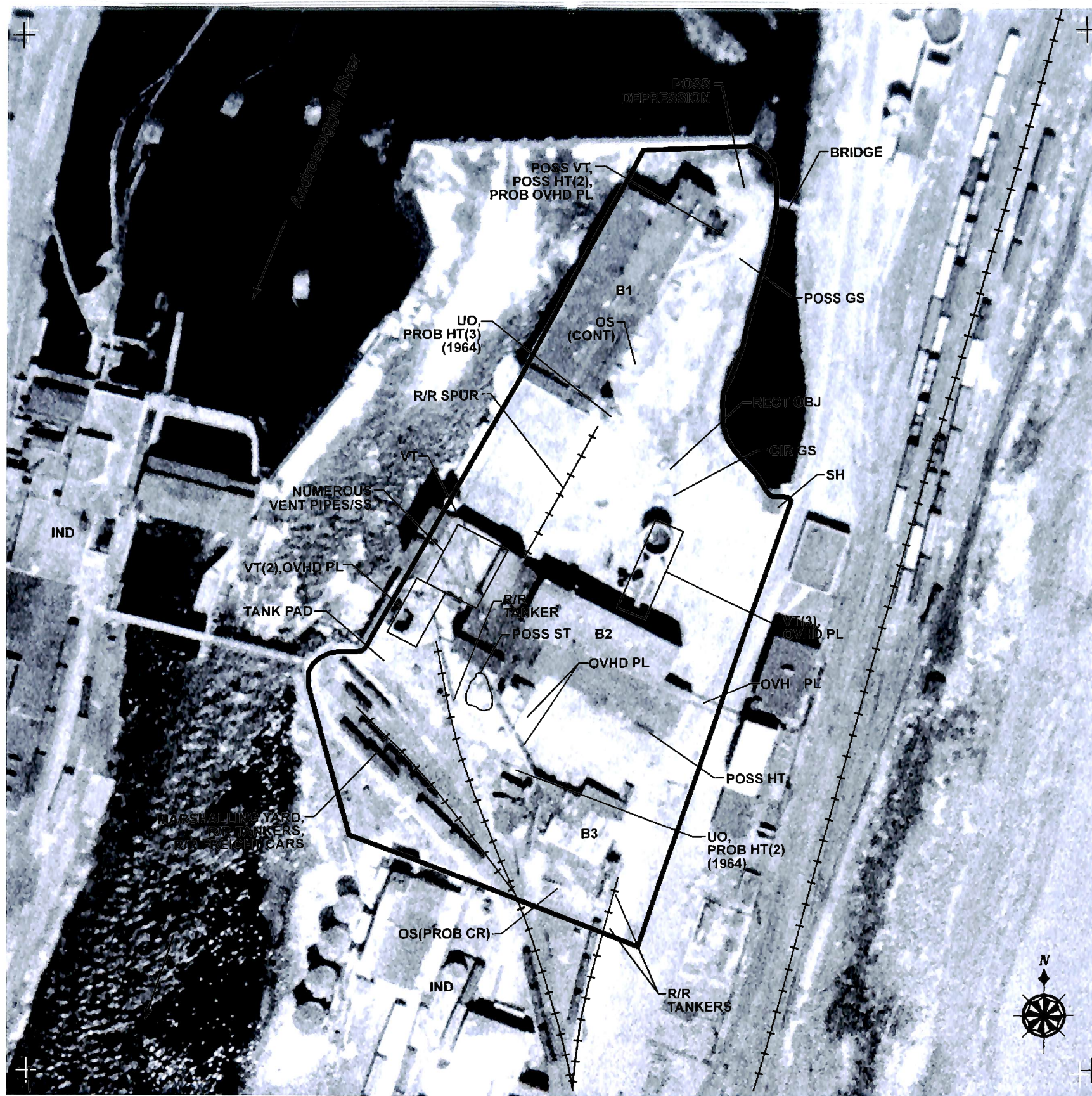
Figure 6. Chlor-Alkali Facility, November 4, 1964. Approximate scale 1:1,475.

MAY 6, 1965 (FIGURE 7)

Buildings B1, B2, and B3 and the small shed remain visible at the site which does not appear to be active at this time. Connected to building B1 by a lattice of probable overhead pipelines are a possible vertical storage tank and two possible horizontal storage tanks. A linear, possible ground scar extends from the building to near the bridge. In 1964, a pipeline, possible ditch, and a patch of dark-toned material were noted at this location. Near the bridge there is a rectangular-shaped possible depression; in 1964 possible saturated material was noted at this location. Containers remain at the open storage area and an unidentified object (UO) is located alongside building B1 at the terminus of the railroad spur remnant. This unidentified object is approximately one-half the height of building B1 and located near to where three probable horizontal storage tanks were seen in 1964.

The grouping of three vertical storage tanks (one of which is open-topped) and a connecting overhead pipeline remain on the north side building B2. Just north of these storage tanks are a rectangular-shaped object (REC OBJ) and a circular-shaped ground scar (CIR GS). The symmetry of this ground scar suggests the former location of a storage tank, but no tank was observed at the location in 1955 or 1964. The grouping of two vertical storage tanks (one of which appears open-topped), overhead pipelines, and large-diameter tank pad remain in place alongside the Androscoggin River. The vertical storage tank located on the northwest side of building B2 remains in place and a possible horizontal storage tank is noted alongside the southeast side of the building. Building B2 remains connected to an offsite building (not annotated) via an overhead pipeline and overhead pipelines continue to connect building B2 to building B3. Adjacent to building B3 is the open storage area housing small probable crates. Also noted near this building is an unidentified object where in 1964, two probable horizontal storage tanks were observed.

In the railroad marshalling yard there are numerous parked railroad tanker cars and several freight cars. Additional railroad tanker cars are located adjacent to building B3.



LEGEND

—	SITE BOUNDARY
←	FLOW
==	ACCESS ROAD
+	RAILROAD
⊖	EXCAVATION/PIT
⊕	MOUNDED MATERIAL
⌋	ESCARPMENT
AR	ACCESS ROAD
B	BUILDING
CA	CLEARED AREA
CIR	CIRCULAR
CONT	CONTAINER
CR	CRATE
CYL	CYLINDRICAL-SHAPED
DER	DERELICT
DG	DISTURBED GROUND
DT	DARK-TONED
FOR	FORESTED
GS	GROUND SCAR
HE	HEAVY EQUIPMENT
HT	HORIZONTAL TANK
IND	INDUSTRIAL
LT	LIGHT-TONED
M	MATERIAL
MM	MOUNDED MATERIAL
OBJ	OBJECT
OS	OPEN STORAGE
OVHD	OVERHEAD
PL	PIPELINE
RECT	RECTANGULAR
RES	RESIDENTIAL
R/R	RAILROAD
SH	SHED
SQ	SQUARE-SHAPED
SS	SMOKESTACK
ST	STAIN
UO	UNIDENTIFIED OBJECT
VEG	VEGETATION
VEH	VEHICLE
VT	VERTICAL TANK

Figure 7. Chlor-Alkali Facility, May 6, 1965. Approximate scale 1:1,475.

SEPTEMBER 14, 1969 (FIGURE 8)

Major portions of buildings B1 and B2, adjoining storage tanks, overhead pipelines, and open storage areas have been removed from the site since 1965. The small shed remains visible and a new building (B4) is noted near building B2. This new building may have originally been part of building B2 seen in previous photographs, but this cannot be confirmed.

Near building B1 is a railroad spur which incorporates the track remnant noted in 1964 and 1965. The spur extends northeast from the railroad marshalling area along the east side of building B1. This spur terminates near a vegetated area (VEG; shrubs) on the shoreline of the Androscoggin River. Two unidentified objects, approximately the size of the hood on an automobile, are located on a thin strip of vegetation (grass). In previous photographs, the southern portion of building B1 was visible here.

Near the shed, located in the northeast section of the site, is a thin mound of light-toned material (LTMM). Adjacent to the mound are a ground scar, likely caused by scraping or heavy equipment, and a small irregularly-shaped patch of possible saturated material. Immediately to the south is a collection of ground scars, disturbed ground (DG), an unidentified object, and dark-toned material. A grouping of ground scars is located where in previous photographs vertical storage tanks were visible.

Near buildings B2 and B4 are possible stained ground, the possible horizontal storage tank seen in 1965, light-toned mounded material, two square-shaped (SQ) objects, and a probable loading platform which is adjacent to the railroad spur (not annotated) seen on previous photographs. Several freight cars are visible on this railroad spur, but no railroad tankers are observed. Immediately west of the freight cars are ground scars and disturbed ground at the location of former building B3.

In the railroad marshalling yard adjacent to the Androscoggin River, there are a rectangular-shaped object and numerous railroad freight cars. No railroad tankers are visible on this photograph. Bordering the river are two large swathes of disturbed ground. Within the area of disturbed ground closest to the railroad marshalling yard there are cylindrical-shaped (CYL) objects and

possible dumping activity. The second area of disturbed ground just to the north includes possible ground stains. Part of this area of disturbed ground was formerly occupied by a section of building B2.

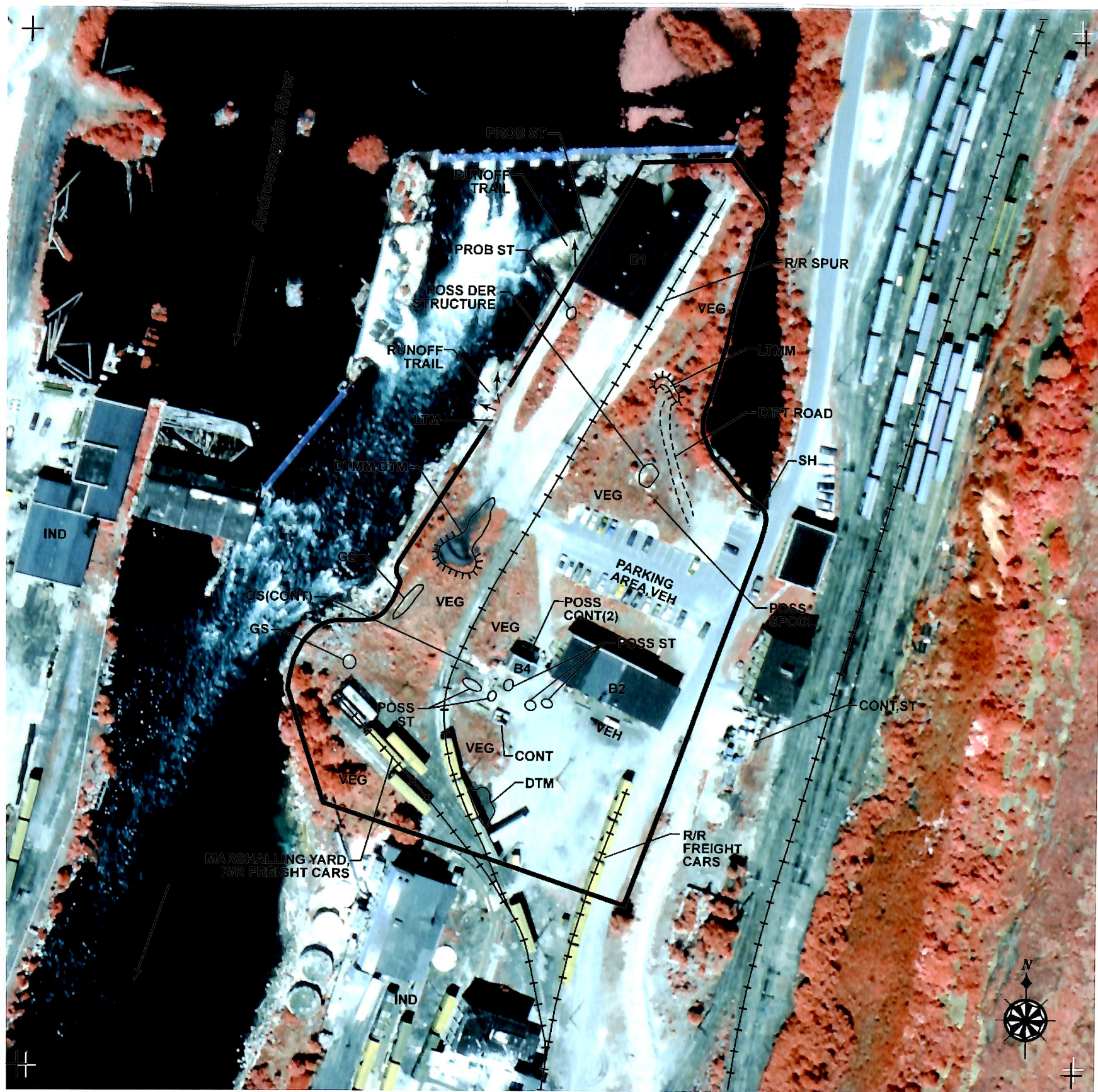
AUGUST 19, 1976 (FIGURE 9)

There are no changes noted to buildings B1, B2, B4 or the shed, but the walking bridge has been removed. Near building B1 there is a probable ground stain on an entrance road (not annotated) into the building. On the retaining wall of the building just above the Androscoggin River, there are two probable stained areas (annotated as one feature due to scale) that appear to emanate from the retaining wall. On two rock outcrops (not annotated) in the river there are darkened runoff trails. One of these runoff trails appears to originate alongside the building. West of the railroad spur there are uniform light-toned material, a combination of uniform dark-toned material and dark-toned mounded material (DTMM), and ground scars. Numerous freight cars are visible in the railroad marshalling yard.

East of the railroad spur there is a narrow dirt road that extends to a mound of light-toned material which was also noted in 1969. Most of the material seen in this area in 1969 has either been removed or cannot be discerned due to vegetation cover. Adjacent to the dirt road are a possible derelict (DER) structure, possibly part of a loading platform, and a large diameter spool likely used for cable. Numerous vehicles (VEH) are located near building B2, indicating activity at the site.

Near buildings B2 and B4 are patches of possible stained ground and an open storage area where light-toned containers are visible. A large, square-shaped container and two possible containers are also observed near these buildings. Near the railroad spur is a patch of dark-toned material.

At an offsite location there are numerous containers and stained ground.



LEGEND

	SITE BOUNDARY
	FLOW
	ACCESS ROAD
	RAILROAD
	EXCAVATION/PIT
	MOUNDED MATERIAL
	ESCARPMENT
AR	ACCESS ROAD
B	BUILDING
CA	CLEARED AREA
CIR	CIRCULAR
CONT	CONTAINER
CR	CRATE
CYL	CYLINDRICAL-SHAPED
DER	DERELICT
DG	DISTURBED GROUND
DT	DARK-TONED
FOR	FORESTED
GS	GROUND SCAR
HE	HEAVY EQUIPMENT
HT	HORIZONTAL TANK
IND	INDUSTRIAL
LT	LIGHT-TONED
M	MATERIAL
MM	MOUNDED MATERIAL
OBJ	OBJECT
OS	OPEN STORAGE
OVHD	OVERHEAD
PL	PIPELINE
RECT	RECTANGULAR
RES	RESIDENTIAL
R/R	RAILROAD
SH	SHED
SQ	SQUARE-SHAPED
SS	SMOKESTACK
ST	STAIN
UO	UNIDENTIFIED OBJECT
VEG	VEGETATION
VEH	VEHICLE
VT	VERTICAL TANK

Figure 9. Chlor-Alkali Facility, August 19, 1976. Approximate scale 1:1,485.

OCTOBER 11, 1982 (FIGURE 10)

The 1982 photographs have less resolution than other photographic coverages used in this report. Therefore, features visible on photographs from the other coverages may not be discernible on the 1982 photographs and the following analysis is not as detailed.

There are no changes noted to buildings B1, B2, B4 or the shed. Railroad freight cars have been removed from the marshalling yard and this yard (railroad ties) has been dismantled. Vegetation areas throughout the site appear unkempt and one possible vehicle is present but the facility is no longer active.

No significant environmental activity is noted west of the railroad spur. East of the railroad spur are several unidentified objects, light-toned objects, and rectangular-shaped objects. These objects range in size from a large truck to approximately one-half an automobile. Possible ground scars, possible disturbed ground, and possible stained ground are also noted.



LEGEND

	SITE BOUNDARY
	FLOW
	ACCESS ROAD
	RAILROAD
	EXCAVATION/PIT
	MOUNDED MATERIAL
	ESCARPMENT
AR	ACCESS ROAD
B	BUILDING
CA	CLEARED AREA
CIR	CIRCULAR
CONT	CONTAINER
CR	CRATE
CYL	CYLINDRICAL-SHAPED
DER	DERELICT
DG	DISTURBED GROUND
DT	DARK-TONED
FOR	FORESTED
GS	GROUND SCAR
HE	HEAVY EQUIPMENT
HT	HORIZONTAL TANK
IND	INDUSTRIAL
LT	LIGHT-TONED
M	MATERIAL
MM	MOUNDED MATERIAL
OBJ	OBJECT
OS	OPEN STORAGE
OVHD	OVERHEAD
PL	PIPELINE
RECT	RECTANGULAR
RES	RESIDENTIAL
R/R	RAILROAD
SH	SHED
SQ	SQUARE-SHAPED
SS	SMOKESTACK
ST	STAIN
UO	UNIDENTIFIED OBJECT
VEG	VEGETATION
VEH	VEHICLE
VT	VERTICAL TANK

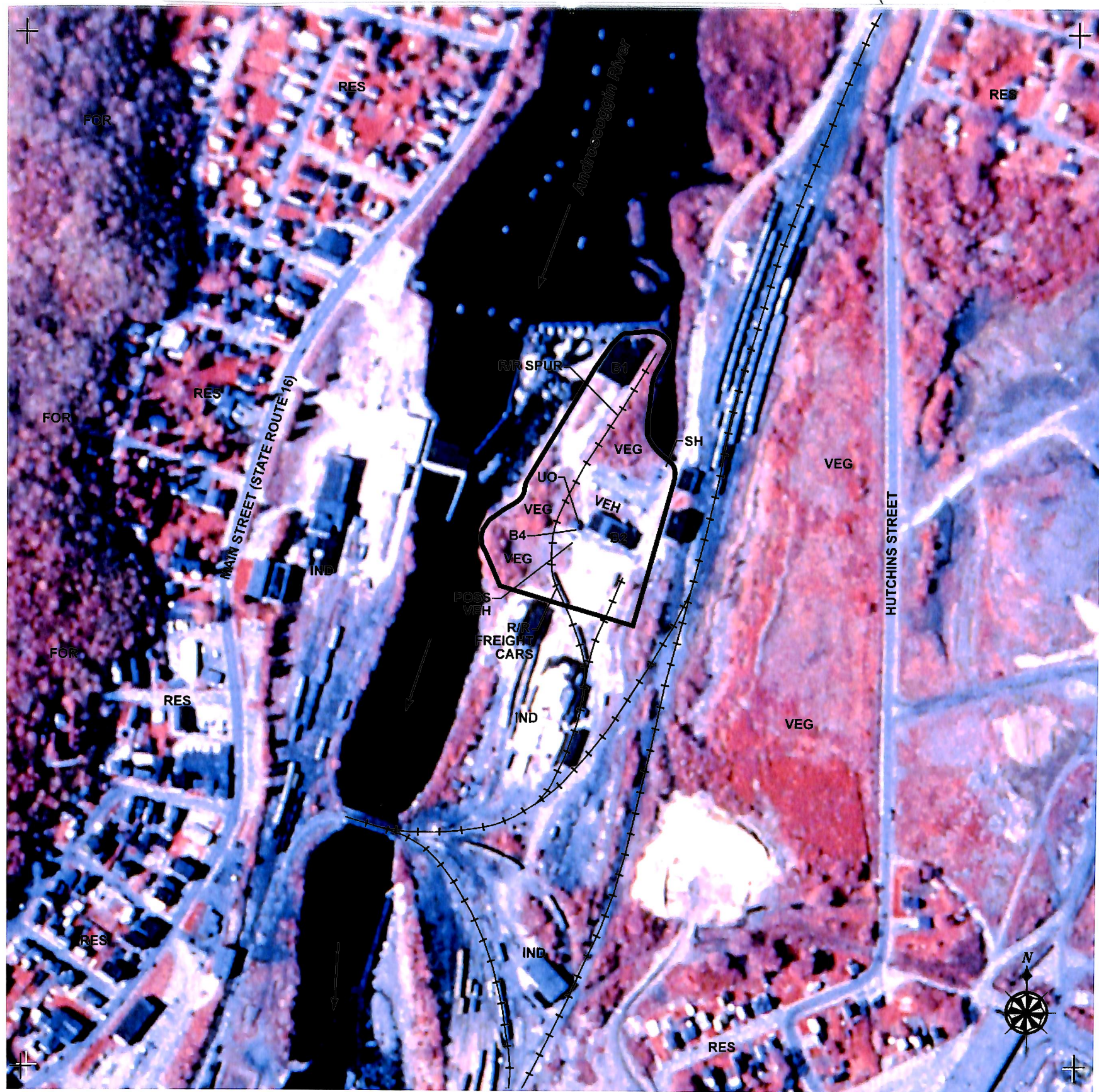
Figure 10. Chlor-Alkali Facility, October 11, 1982. Approximate scale 1:3,600.

MAY 13, 1986 (FIGURE 11)

The 1986 photographs have less resolution than other photographic coverages used in this report. Therefore, features visible on photographs from the other coverages may not be discernible on the 1986 photographs and the following analysis is not as detailed.

There are no changes noted to buildings B1, B2, B4 or the shed. Vegetation areas throughout the site appear unkempt. Several vehicles, a possible vehicle, and railroad freight cars are visible on the railroad spur but the facility is no longer active.

No significant environmental activity is noted west of the railroad spur. East of the railroad spur is an unidentified object approximately one-half the size of an automobile.



LEGEND

	SITE BOUNDARY
	FLOW
	ACCESS ROAD
	RAILROAD
	EXCAVATION/PIT
	MOUNDED MATERIAL
	ESCARPMENT
AR	ACCESS ROAD
B	BUILDING
CA	CLEARED AREA
CIR	CIRCULAR
CONT	CONTAINER
CR	CRATE
CYL	CYLINDRICAL-SHAPED
DER	DERELICT
DG	DISTURBED GROUND
DT	DARK-TONED
FOR	FORESTED
GS	GROUND SCAR
HE	HEAVY EQUIPMENT
HT	HORIZONTAL TANK
IND	INDUSTRIAL
LT	LIGHT-TONED
M	MATERIAL
MM	MOUNDED MATERIAL
OBJ	OBJECT
OS	OPEN STORAGE
OVHD	OVERHEAD
PL	PIPELINE
RECT	RECTANGULAR
RES	RESIDENTIAL
R/R	RAILROAD
SH	SHED
SQ	SQUARE-SHAPED
SS	SMOKESTACK
ST	STAIN
UO	UNIDENTIFIED OBJECT
VEG	VEGETATION
VEH	VEHICLE
VT	VERTICAL TANK

Figure 11. Chlor-Alkali Facility, May 13, 1986. Approximate scale 1:3,560.

MAY 14, 1994 (FIGURE 12)

The 1994 photographs have less resolution than other photographic coverages used in this report. Therefore, features visible on photographs from the other coverages may not be discernible on the 1994 photographs and the following analysis is not as detailed.

There are no changes noted to buildings B1, B2, B4 or the shed; however, all railroad lines have been removed from the site. Vegetation areas throughout the site appear unkempt. Two semi-trailers, possible heavy equipment (HE), and a vehicle are noted at the site. Near the trailers are light-toned mounded material and a large cleared area (CA) which forms a depression. Several small, unidentified objects are noted within this cleared depression. Near buildings B2 and B4 are a larger unidentified object and an open storage area where crates or containers are neatly arranged in three evenly spaced rows.



LEGEND

	SITE BOUNDARY
	FLOW
	ACCESS ROAD
	RAILROAD
	EXCAVATION/PIT
	MOUNDED MATERIAL
	ESCARPMENT
AR	ACCESS ROAD
B	BUILDING
CA	CLEARED AREA
CIR	CIRCULAR
CONT	CONTAINER
CR	CRATE
CYL	CYLINDRICAL-SHAPED
DER	DERELICT
DG	DISTURBED GROUND
DT	DARK-TONED
FOR	FORESTED
GS	GROUND SCAR
HE	HEAVY EQUIPMENT
HT	HORIZONTAL TANK
IND	INDUSTRIAL
LT	LIGHT-TONED
M	MATERIAL
MM	MOUNDED MATERIAL
OBJ	OBJECT
OS	OPEN STORAGE
OVHD	OVERHEAD
PL	PIPELINE
RECT	RECTANGULAR
RES	RESIDENTIAL
R/R	RAILROAD
SH	SHED
SQ	SQUARE-SHAPED
SS	SMOKESTACK
ST	STAIN
UO	UNIDENTIFIED OBJECT
VEG	VEGETATION
VEH	VEHICLE
VT	VERTICAL TANK

Figure 12. Chlor-Alkali Facility, May 14, 1994. Approximate scale 1:3,600.

FRACTURE TRACE ANALYSIS

Fracture trace analysis is the technique of using aerial imagery for locating fracture traces or geologic lineaments on the earth's surface based on the photo-geologic signatures such as soil-tonal variations and vegetational and topographic alignments. Fracture traces are considered to be the surface expressions of vertical-to-near-vertical zones of fracture concentration in bedrock (see Methodology section).

The fracture trace study area analyzed for this report covers an approximate 41 square kilometer (16 square miles) area, centered on the Chlor-Alkali Facility. The study area is located in Coos County, New Hampshire, and is situated in the New England physiographic province. The bedrock geology of the study area includes Ordovician age metamorphosed biotite-quartz monzonite of the Oliverian Plutonic Suite which underlies the Androscoggin River valley. The surrounding uplands in the study area are underlain by Ordovician age gneisses and amphibolites of the Ammonoosuc Volcanics. The rocks of the Oliverian Plutonic Suite intrude those of the Ammonoosuc Volcanics (Degnan, J.R., et al., 2005).

The fracture trace analysis was conducted using 1964 large-scale photographs (1:18,000 scale), 1982 medium-scale photographs (1:40,000 scale), and geologic literature describing the area. A total of seven (7) fracture traces were identified and are presented on an overlay to a print produced from a 1986 photograph (see Figure 13). Two lineaments are presented in a study by Degnan, J.R., et al., (2005). One lineament is located north of the Chlor-Alkali Facility along the east bank of the Androscoggin River and the other in the upland area southeast of the facility. These two lineaments were identified using high altitude aerial photography with an approximate scale of 1:80,000 (Degnan, J.R. et al., 2005). An unsuccessful effort was made to corroborate the location of these two lineaments on the medium- to large-scale photographs used in this report. The lack of success may be attributable to the differences in the scale of photography used in the separate studies.

All of the seven fracture traces identified in this fracture trace analysis are situated in the upland portion of the study area and are underlain by Ammonoosuc Volcanics. Urban development along the Androscoggin River valley has obscured or destroyed any evidence of fracture traces in the area underlain by the Oliverian Plutonics. None of the seven fracture traces were identified extending across the interface between the two bedrock units (Oliverian Plutonics and Ammonoosuc Volcanics) underlying the study area. Therefore no fracture trace induced hydrologic connectivity between the bedrock units can be inferred from this analysis. However, if fracture traces "A" and "B" (see Figure 13) are extended to the northwest into the Oliverian Plutonics of the urban developed lowland area, the two extended traces intersect at the Androscoggin River near the southwest corner of the Chlor-Alkali Facility. This intersection point may possibly identify a zone of fractured bedrock that preferentially directs ground-water flow toward the facility.

Caution, however, should be exercised if the fracture traces identified in this analysis and annotated on Figure 13 are to be used for determining the placement of groundwater monitoring wells. Differences of a few meters can determine whether or not a well is located on a given fracture trace. Thus, it is recommended that the geologic field personnel tasked with determining the placement of the wells utilize stereo diapositives and photographic interpretive equipment as part of their field operations.

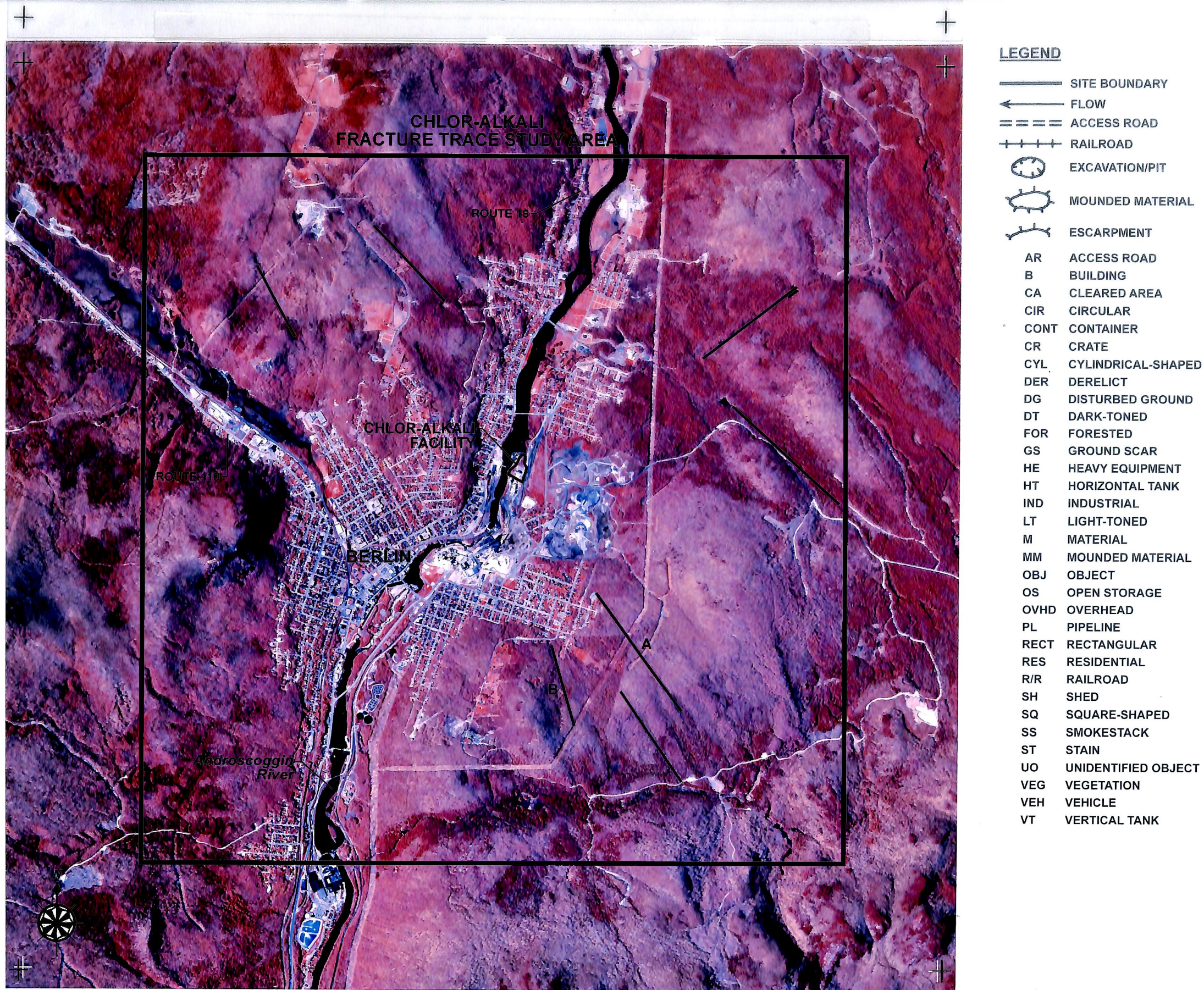


Figure 13. Chlor-Alkali Facility, fracture trace analysis, May 13, 1986.
Approximate scale 1:35,110.

GLOSSARY

Access Road (AR) - A paved or unpaved route of vehicular access.

Building (B) - A relatively permanent, essentially boxlike construction having a roof.

Cleared Area (CA) - An area from which man has removed trees, shrubs, or other natural vegetative cover.

Container (CONT) - Any portable device in which material is stored, transported, handled, or disposed.

Dark- (DT), Medium- (MT), or Light-Toned (LT) - Tones of features in question are compared with the darkest and lightest tones of gray (if using B&W photography) on the print.

Disturbed Ground (DG) - A rough area where the ground surface has been dug up or overturned.

Ground Scar (GS) - An area of bare soil, apparently the result of human activity.

Material (M) - Raw or waste materials on or in the vicinity of the site.

Mounded Material (MM) - Piles of raw or waste materials on or in the vicinity of the site.

Open Storage Area (OS) - An area of open-air (outdoor) storage of containerized, raw or waste materials, within industrial or manufacturing sites.

Stain (ST) - A residue or discoloration resulting from a spill, discharge, or removed/dispersed materials.

Tanks - Vertical tanks (VT), horizontal tanks (HT), pressure tanks (PT), tank farms, and solid waste management units. A large receptacle, container, or structure for holding liquid or gas.

REFERENCES

MAPS

Source ^a	Figure	Name	Scale	Date
USGS	1	United States	1:2,500,000	1972
USGS	2	Berlin, NH	1:24,000	1995
EDR	3	Berlin, NH	1:960	1928
EDR	4	Berlin, NH	1:960	1955

COLLATERAL INFORMATION

EPA. 2007. Collateral data and site map supplied by EPA Region 1 as attachment to Remote Sensing Services Request Form.

LMS (Lockheed Martin Services). 2006. Master Quality Assurance Project Plan. Prepared for EPA Environmental Sciences Division. Contract EP-D-05-088. Las Vegas, Nevada.

EDR (Environmental Data Resources). 2007. Sanborn maps, Berlin, New Hampshire. 1928 and 1955 maps - Certification # 7B61-4F0E-9EDE.

Degnan, J.R., Stewart F. Clark, Jr., Philip T. Harte, and Thomas J. Mack, 2005. Geology and Preliminary Hydrogeologic Characterization of the Cell-House Site, Berlin, New Hampshire, 2003-04, U.S. Geological Survey Scientific Investigation Report 2004-5282, 55 p.

AERIAL PHOTOGRAPHS

Photo source ^a	Figure ^b	Date of acquisition	Original scale	Film type ^c	Mission I.D.	Source frame #	EPIC ID #
ASCS	5	08-04-55	1:20,000	B&W	DXU	50-52	134785-134787
AVPT	6	11-04-64	1:18,000	B&W	1320	7395-7397	136289-136291
USGS ^d	7	05-06-65	1:24,000	B&W	VARQ	124,125	DI0000135
USGS ^d	8	09-14-69	1:18,000	CIR	MX104	1584-1586	DI0000136
ASCS	-	10-20-70	1:20,000	B&W	OXU	2-4	134788-134790
EPA	9	08-19-76	1:9,600	CIR	7767	76-215:14,15	-
EPA	-	08-23-77	1:25,000	CIR	7729	77-202:31,32	-
ASCS	10	10-11-82	1:40,000	B&W	33007	106-108	134791-134793
USGS	11,13	05-13-86	1:58,000	CIR	447007	126,127	134794,134795
ASCS	12	05-14-94	1:40,000	B&W	NAPP	45,46	134796,134797

^aASCS U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service, Salt Lake City, Utah

AVPT Aerial Viewpoint, Inc., Spring, Texas

EPA U.S. Environmental Protection Agency, Environmental Sciences Division, Las Vegas, Nevada

USGS U.S. Department of Interior, U.S. Geological Survey, Washington, D.C.

^bPhotographs listed with no figure number were analyzed but not placed in this report.

^cB&W Black-and-white

CIR Color infrared

^ddigital diapositive (see Methodology section)